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THUJA

(thujas or arborvitae)

The thujas (*Thuja*) are called arborvitae in horticulture, but the 2 North American representatives are known as cedars. Four other species of this small genus are native in eastern Asia in Japan, Korea, and mainland China.

The native species have fibrous, shreddy, brown bark. The twigs are flattened usually in horizontal plane, much branched, forming fanlike sprays. The small scalelike, short-pointed, yellow-green leaves are paired or opposite in 4 ranks, mostly shedding with the twigs after several years.

Male and ovulate strobili are borne singly at the ends of different twigs on a tree. The upright cones, small and egg-shaped, mature in one season but remain attached until the next spring. They are composed of 8 to 12 paired, hard scales, the middle scales bearing usually 2 seeds, mostly winged on edges. Cotyledons 2.

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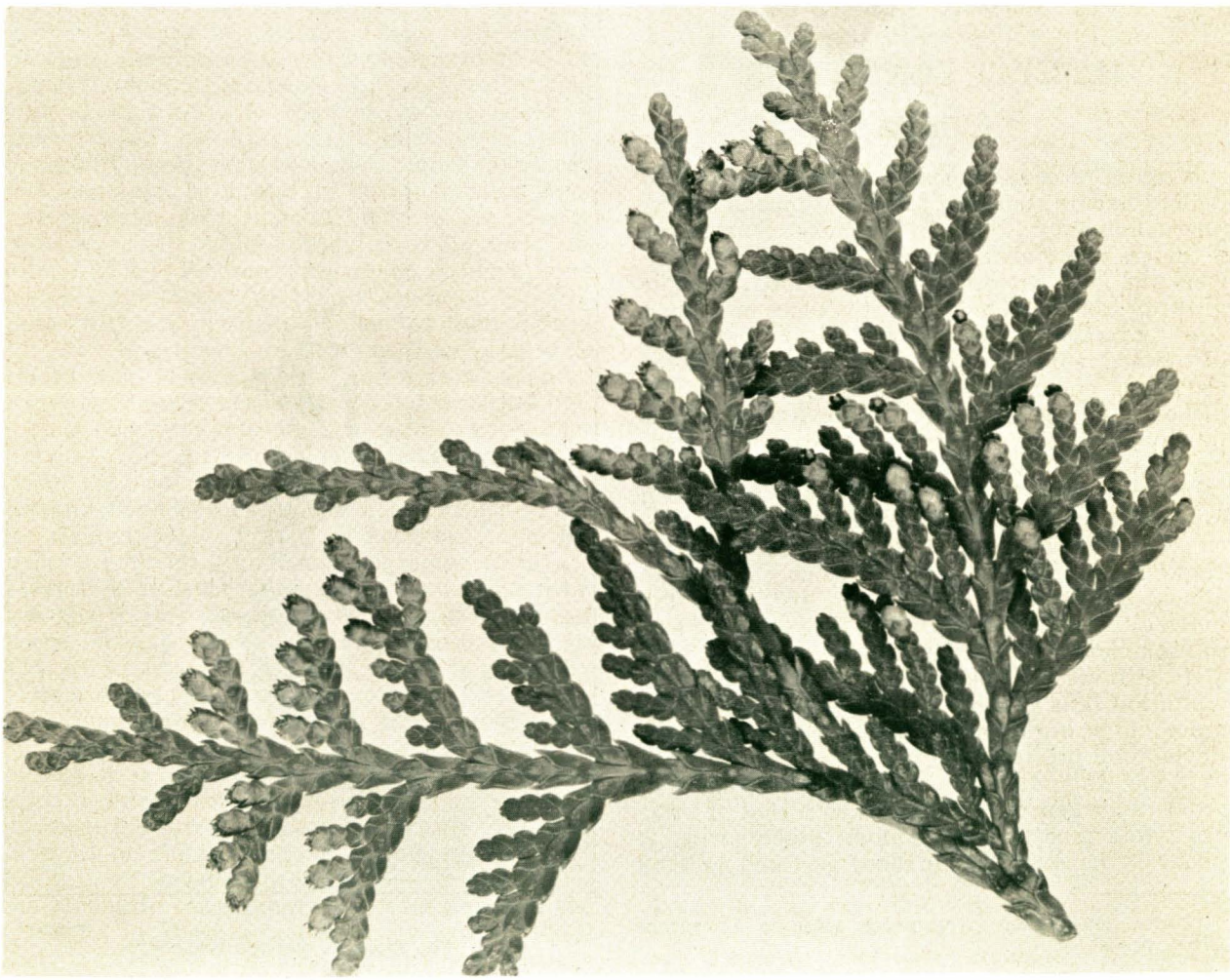


WESTERN REDCEDAR (*Thuja plicata* Donn)

Other common names: Giant arborvitae, canoe cedar, shinglewood, Pacific redcedar, giant cedar, arborvitae, and cedar.

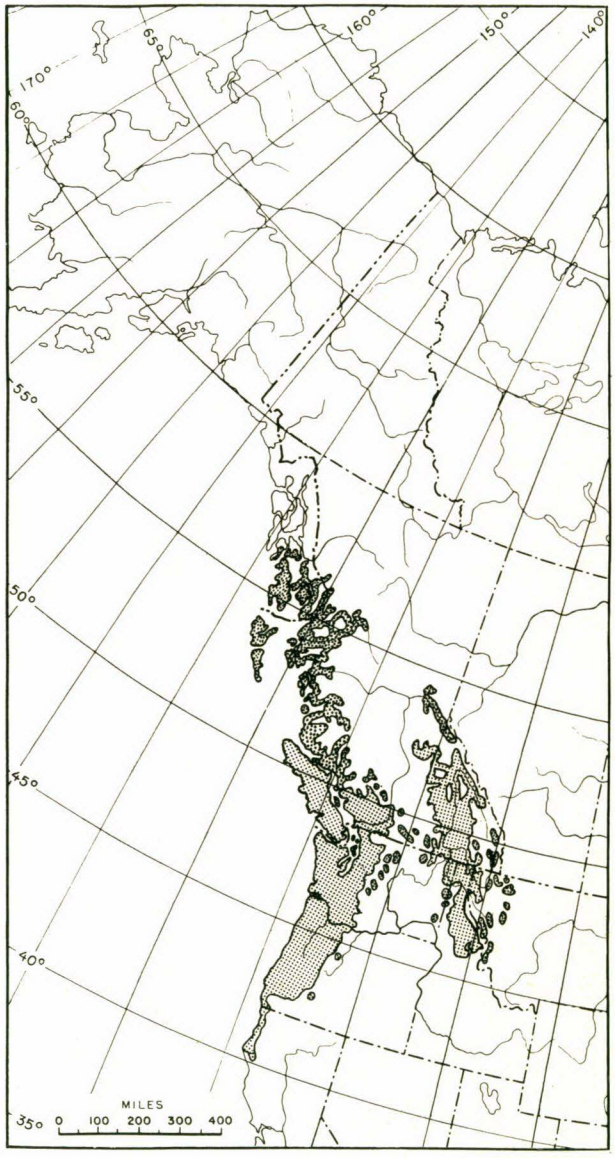
Western redcedar grows from the coastal regions of southern Alaska from Sumner Strait (*1*)[1] south through the coastal ranges of British Columbia, through western Washington and Oregon to Humboldt County, Calif. In British Columbia it grows east to the western slope of the Continental Divide at latitude 54° 30′ N. and thence south into the Selkirk, Bitterroot, and Salmon River Mountains of Idaho. Its easternmost limit is the western slope of the Rocky Mountains in northern Montana. In Oregon western redcedar is found on both sides of the Cascade Range. On the west side it is found as far south as Crater Lake, while on the eastern slopes it is limited to the vicinity of Mount Hood. It is rather uncommon in California and is confined to the ocean side of the coast ranges within the fog belt. Throughout its range it occupies the humid transition and Canadian zones.

HABITAT CONDITIONS

Climate

Western redcedar is confined almost entirely to regions having abundant precipitation and atmospheric humidity (*27*). In the Puget Sound area it thrives under abundant rainfall with cool summers and mild winters; here is its most favorable growing condition, and here it reaches maximum size. Average annual rainfall within the range of western redcedar varies from 30 to 60 inches at elevations up to 1,000 feet, and upwards to 100 inches at higher altitudes. Three-fourths of the precipitation falls during the wet season (November to April). In the Puget Sound area summer rains are infrequent. Within the fog belt, which extends about 30 miles inland from the coast, precipitation varies from 60 to 130 inches and includes fairly frequent summer rains. The mean annual temperature varies from 46° F. in the north to 52° in the south. The long growing season commences in April in the Puget Sound area and continues until September. Little of the precipitation falls as snow in the coastal and Sound areas, but at higher elevations a considerable part of the total precipitation is snow.

In the InlandEmpire, where the western redcedar range generally coincides with that of western white pine, average annual precipitation is about 28 inches in the northern part and 32 to 49 inches in the middle and southern parts. The frost-free period ranges from 60 to 160 days in the Inland Empire. The climate is characterized by a short summer season having scanty precipitation, rather low humidities, and a high percentage of clear days. Winters are long, snowfall is heavy,



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The range of western redcedar.

[1] Italic numbers in parentheses refer to Literature Cited, p. 690.

and temperatures are fairly low. Precipitation in the Inland Empire is classified as the sub-Pacific type—distinguished from the Pacific type by the fact that in this sub-Pacific type only a small amount of the total precipitation falls in winter, whereas large amounts fall in spring and fall. Thirty-five percent of the total precipitation in the Inland Empire falls as snow; 50 percent is divided equally between spring and fall; 7½ percent falls in June, and the remainder is divided equally between July and August. Average annual temperatures range from 42° F. in the central part of the region to 50° at its southern border.

Soils and Topography

Little is known about the optimum soil texture classes and types for western redcedar. Occasionally redcedar grows on moderately dry and warm sites, but its growth is poor (*27*). One study showed that cedar requires soil conditions in which moisture does not fall below 12 percent in August (*19*). In a study of soil characteristics of widely scattered stands in northern Idaho representing the three associations in which cedar is climax, the pH in the first 5 decimeters of mineral soil varied from about 5.1 to 7.1. Most of the soils could be characterized as slightly to moderately acid. Spruce-fir associations located at higher elevations have more acid soils, and the lower elevation associations have less acid soils, but none are strongly basic. Soils under individual cedar trees exhibit higher pH than soils under hemlock trees in the same stand (*4*). This condition is associated with a high calcium content of cedar foliage (*5*, *28*). Moisture equivalents in these same soils varied from 11 to 82 percent and thus represented a very wide range of soil texture and structure (*3*).

Both droughty soil-moisture regimes and a continuously high water table impaired the growth of cedar on Vancouver Island. The fertile, occasionally flooded soils of the Pseudotsuga—Thuja—Adiontun Association is near optimum for cedar growth in the Douglas-fir region (*20*).

Western redcedar is generally found on stream bottoms, moist flats, terraces, and gentle lower slopes and in moist gulches and ravines (*21*, *27*). The environment of a north aspect is generally more suitable than a southern aspect.

Throughout its north-south range on the Pacific coast it is found as low as sea level. In Alaska it is confined to the islands and to the western side of the coastal ranges to an elevation of about 3,000 feet. In coastal British Columbia it grows on the islands and extends up the coast range to an elevation of 2,400 feet. In the Olympic Mountain coast ranges and west slopes of the Cascades in Washington it rarely exceeds 4,000 feet. In Oregon it generally grows to elevations of 5,000 feet, but in one location it is found at 7,000 feet. On the east slope of the Washington Cascades and in the northern Rocky Mountain region of northeastern Washington, northern Idaho, and Montana, it is found between 2,000 to 7,000 feet (*27*). The upper limit in the British Columbia Selkirk range is 4,500 feet (*10*). Within the United States its growth is not commercially important above the 3,000-foot elevation in the coastal region or above 5,000 feet in the Inland Empire (*27*).

Associated Trees and Shrubs

Western redcedar is a major component of the Western Redcedar (Type 228) and Western Redcedar—Western Hemlock (Type 227) cover types. It occurs also in these types: Engelmann Spruce—Subalpine Fir (Type 206), Larch—Douglas-Fir (Type 212), Western White Pine (Type 215), Sitka Spruce (Type 223), Western Hemlock (Type 224), Sitka Spruce—Western Hemlock (Type 225), Pacific Douglas-Fir (Type 229), Douglas-Fir—Western Hemlock (Type 230), Port-Orford-Cedar—Douglas-Fir (Type 231), and Redwood (Type 232). Types 225, 227, and 228 are climax.

In an ecological classification of vegetation in the northern Rocky Mountain area, western redcedar is in three habitat types: the Thuja-Tsuga/Pachistima, the Thuja-Tsuga/Oplopanax, and the Thuja/Pachistima Associations (*4*).

Western redcedar seldom occurs in pure stands and then only over small areas. In Oregon, western Washington, and northward along the Pacific coast, western hemlock, Sitka spruce, grand fir, Douglas-fir, Port-Orford-cedar, and Pacific silver fir are common associates. In California it grows in mixture with redwood and western hemlock. Bigleaf maple, red alder, and northern black cottonwood commonly grow with cedar on very wet or swampy areas in the coastal region. In the upper Cascade Mountains it grows with Pacific silver fir, Alaska cedar, mountain hemlock, western white pine, and noble fir (*23*). In the northern Rocky Mountains, western white pine, western larch, lodgepole pine, grand fir, Engelmann spruce, subalpine fir, western hemlock, and northern black cottonwood are commonly associated with cedar (*13*). Its Alaskan associates are western hemlock and Sitka spruce (*29*).

Dense stands of western redcedar and its associates exclude nearly all subordinate vegetation; but when stands are at all open, the forest floor abounds in a wide variety of mosses, ferns, herbs, and shrubs. In the northern Rocky Mountains the most common shrubby associates are *Acer glabrum* var. *douglasii*, *Amelanchier alnifolia*, *Arctostaphylos uva-ursi*, *Ceanothus velutinus*, *Lonicera utahensis*, *Menziesia ferruginea*,

Oplopanax horridus, *Pachistima myrsinites*, *Physocarpus malvaceus*, *Ribes lacustre*, *R. viscosissimum*, *Rosa gymnocarpa*, *R. spaldingi*, *Rubus pedatus*, *Salix barclayi*, *S. bebbiana*, *S. scouleriana*, *S. sitchensis*, *Sorbus scopulina*, *Spiraea betulifolia*, *Symphoricarpos albus laevigatus*, and *Vaccinium membranaceum* (*4*).

Most of these species occur both in the coastal redcedar forests and in the Rocky Mountain forests. In addition, the following species are plentiful in the coastal forests: *Acer circinatum*, *Mahonia nervosa*, *Cornus nuttallii*, *C. pubescens*, *C. stolonifera*, *Corylus californica*, *Gaultheria shallon*, *Holodiscus discolor*, *Osmaronia cerasiformis*, *Malus fusca*, *Sambucus callicarpa*, and a number of species of *Betula*, *Ribes*, *Rubus*, *Salix*, and *Vaccinium* not found in Inland Empire (*17*).

LIFE HISTORY

Reproduction and Early Growth

Flowering, seed production, and dissemination.—On the warmer sites flowering commences as early as mid-April but at higher elevations flowering may be delayed until late May or early June.

In most areas the cones mature by late August, and seedfall starts in late August or early September. In the Inland Empire seedfall was observed to be light in September, heaviest in October, and from 34 to 40 percent of the seed fall after November 1. Some seedfall continues throughout the winter in most areas (*13*). On the west coast of Vancouver Island 90 percent of the cedar and hemlock seed fell during dry, cold weather with relative humidities below 50 percent. Peak seedfall occurred during November. There were no variations in germinative capacity related to time of seedfall (*14*).

Western redcedar is a prodigious seed producer, ranking second only to western hemlock among the associated species (*13*). Average annual seed crops of 100,000 to 1,000,000 seed per acre in stands with as much as 25 percent western redcedar have been reported in British Columbia (*24*). In the same area seed crops as great as 57,000,000 seed per acre within a stand of 67 percent cedar have been reported. In the Inland Empire 111,000 seeds per acre per year were found over a 7-year period on cutover areas.

A 14-year record of cone crops in the Inland Empire showed the average interval between good western redcedar cone crops to be 2.8 years. During an 8-year period in which detailed records were kept, western redcedar produced good crops 4 years, fair crops 3 years, and a poor crop only 1 year (*13*). In studies of seed production in British Columbia, a seed yield of 1,500,000 per acre from a fair crop on four bearing trees per acre has been reported (*9*). Cedar bore seed at the age of 16 years on the 1910 burn in northern Idaho (*22*).

Seed is dispersed by wind, but its relatively small wing surface causes its rate of fall to be faster and seed flight shorter than that of any of its associates (*26*). In seed release experiments in the coastal forests, western redcedar seed was not dispersed more than 400 feet from its source when released at 150-foot elevation (*15*).

Seedling development.—The seed of western redcedar is eaten less by rodents than that of its larger seeded associates. Direct seeding experiments in the Inland Empire (*25*) and in the coastal forests (*16*) have shown that the small seeds of western redcedar need no protection from rodents for successful establishment of a stand. This is probably true of naturally cast seed as well.

Depending on weather conditions, seeds germinate in the fall or early in the spring (*13*, *18*). In the coastal areas, fall germination and seedling establishment are common (*18*). Spring germination is more common in the Rocky Mountains (*16*).

Compared to other species in the western white pine type, cedar has the highest germination percentage: cedar, 73 percent; hemlock, 65 percent; western white pine, 44 percent; and grand fir, 12 percent (*13*). In greenhouse germination studies where a favorable degree of moisture was maintained, there were no differences in germination on ash, duff, mineral soil, and rotten wood surfaces (*7*). Under natural conditions, however, germination is better on burned and unburned mineral surfaces than on duff. Rapid drying of the duff and the small size of cedar seeds probably account for the poor germination on duff (*13*).

Although seed production of western redcedar is prodigious, rodent depredations of the seeds are minor, and germination percentage is excellent under most conditions, very few seeds develop into established seedlings. First-year seedling mortality varied from 44 percent in a seed-tree cutting (*13*) to 97 percent under a dense cedar overwood (*31*). In the same seed-tree cutting, the 6-year mortality was 74 percent.

Early first season losses of seedlings of as much as 47 percent from fungi, birds, and insects have been observed. After seedlings start to harden, insolation and drought cause more loss. In full sunlight few of the relatively succulent cedar seedlings survive the high soil surface temperatures. Seedlings survive best under partial shade. In full shade the seedlings make very poor top and root growth and soon die of drought. Among the associated trees in the northern Rockies (*13*) only western hemlock has poorer seedling root penetration than cedar.

Fallen leaves of deciduous shrubs cause mortality on cutover areas by smothering the seedlings. This is a primary cause of low survival on areas seeded to western redcedar (*25*).

Vegetative reproduction.—Cedar can be reproduced vegetatively; natural regeneration by this means appears to be common in some areas (*24*). In old growth stands on good sites in British Columbia, most of the advanced reproduction may be vegetative. Adventitious roots may develop on low hanging limbs, from the trunks of fallen trees that remain alive, or from living branches that fall on a wet soil surface. Growth of such reproduction is very slow. Vegetative propagation is not common in stands within the United States.

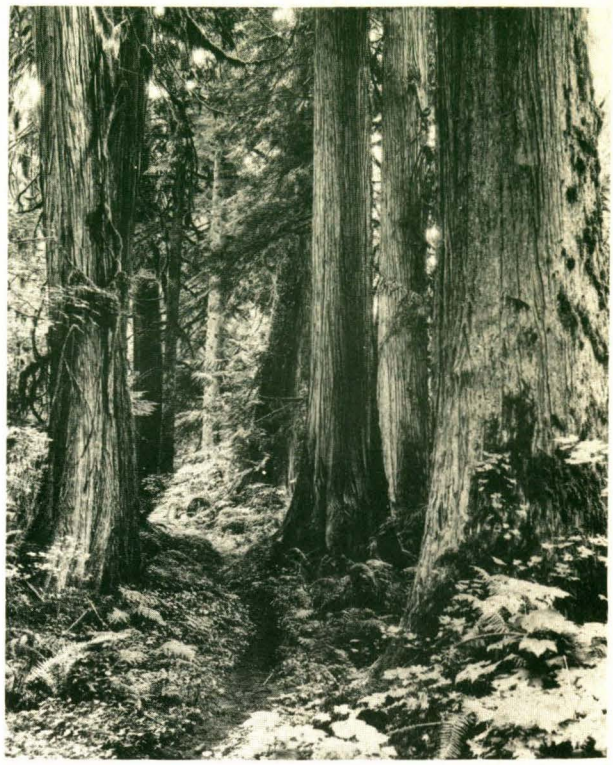
Sapling Stage to Maturity

Growth and yield.—Compared to most of its associates, western redcedar is a slow growing species. In young thrifty stands in the Puget Sound area, periodic annual diameter growth varies from a peak of 0.34 inch in the third decade to 0.20 inch in the seventh decade. Height growth in the second decade was maximum at 2.3 feet annually and declined to 0.61 foot in the seventh decade. At 80 years, the average diameter was 19 inches; height, 101 feet; and volume, 57 cubic feet or 298 board feet per tree. Periodic annual volume growth had increased from 4.9 board feet per tree during the fifth decade to 6.4 feet per tree in the seventh (*18*).

In a mature stand grown under partial suppression, diameter growth was nearly uniform (varying from 0.12 to 0.18 inch per year) for nearly 200 years. Height growth was most rapid before the 30th year but was also steadily sustained for 200 years, ranging from 1.0 to 0.53 foot per year. The average diameter at 80 years was 9.35 inches and the average height 63.3 feet. Volume at 80 years was 11.5 cubic feet or 55 board feet per tree. Periodic annual board foot growth per tree was 1.8. At 200 years the average diameter was 29.3 inches; height, 131.1 feet; volume, 152 cubic feet or 850 board feet per tree. Annual growth was 11.0 board feet per tree (*18*).

Under the most favorable growing conditions in the Puget Sound area cedar reaches enormous size: heights in excess of 200 feet, and diameters up to 16 feet (*30*). In the northern Rockies the larger trees are 175 feet tall and 8 feet in diameter (*21*).

Estimated yields in some of the best northern Idaho mixed redcedar stands are from 25,000 to 30,000 board feet per acre. Pure stands of redcedar of limited extent may yield from 60,000 to 70,000 board feet per acre (*21*). Stands in the western white pine type that contains cedar and hemlock generally have smaller yields than do stands in which these species are not abundant (*12*).



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Old growth western redcedar in the Mt. Baker National Forest, Wash.

British Columbia empirical yield tables for various zones within the province show yields on good sites at 130 years to be from 10,429 cubic feet in the southwest coastal areas to 4,665 cubic feet in the southeastern interior of the province. Old growth stands in the southern coastal areas with an average age of 375 contained an average of 15,255 cubic feet when mixed with Douglas-fir (*2*).

Reaction to competition.—Cedar is classed as a very tolerant tree and, in fact, it germinates, grows, and even reaches maturity in the shade. Its growth is retarded in proportion to the density of the shade, however; and when competition is removed, cedar responds well to the increase in growing space. In some localities it apparently does not fill all of the requirements of a tolerant species, however. Reports from British Columbia (*24*) describe mature commercial stands that have a notable absence of the younger diameter classes of cedar associated with abundant regeneration of western hemlock and white fir. Only in open-grown noncommercial stands of the "cedar scrub" was there a distribution of diameter classes typical of tolerant species. This lack of advanced reproduction under heavy shade is attributed to germination failures or seedling mortality rather than

to the lack of ability of the species to survive under competition. Similar conditions have been reported in southeastern Alaska, where germination appears to be adequate but seedlings fail to survive (*11*).

Principal enemies.—Redcedar has few important natural enemies other than fire to which its thin, fibrous bark and shallow roots make it very susceptible (*18*, *21*). Studies in the coastal forests have shown that cedar is more severely damaged by surface fires than any of its associates. In Inland Empire stands, its relative fire resistance is rated as low-medium; Engelmann spruce, western hemlock, and alpine fir, in this order, are more susceptible. The hot fires common in this region generally erase all evidence of differences in fire resistance between species except that western larch and Douglas-fir seem to have somewhat better survival than others (*8*).

On the drier sites cedar withstands destructive winds quite well. On very wet soils, the shallow root system makes it subject to windthrow (*18*). Tentative ratings of the windfirmness of Inland Empire species place redcedar fourth, exceeded by western larch, ponderosa pine, and Douglas-fir.[2]

Cedar has few insect enemies and suffers little from their damage (*18*). The western cedar borer (*Trachykele blondeli*) mines into the sapwood and heartwood of living, dying, and dead cedar. A round-headed borer, the amethyst cedar borer (*Samanotus amethystinus*), occasionally kills healthy trees, but usually limits its attacks to injured or dying trees. Its range is limited to the coastal cedar forests. The western cedar bark beetle (*Phloeosinus punctatus*) is a widespread species that attacks trunks and larger limbs and has been known to kill trees. Other less destructive insects that may occasionally damage are the western hemlock looper (*Lambdina fiscellaria lugubrosa*), various cedar twig and leaf miners of the genera *Gnathotrichus* and *Trypodendron*, and various bark beetles of the genus *Phloeosinus*.

Cedar is not plagued by fungi to the extent that its associates are, but losses can strongly influence management. In British Columbia decay in stands 50 to 450 years old does not exceed growth increment but decay in younger stands is more important than previous reports had indicated (*3*). The following species of fungi are of decreasing order of importance for the coastal areas: *Poria asiatica*, *P. albipellucida*, *Fomes pini*, *Merulius* sp., and *Poria subacida*. In the interior, where losses from decay and incidence of infection are appreciably higher, species are as follows: *Poria asiatica*, *P. weirii*, *Fomes pini*, *Polyporous balsameus*, *Merulius* sp., and *Poria subacida*. Other extensive but less important fungi attacking the heartwood of living trees are *Fomes annosus*, *F. nigrolimitatus*, *F. pinicola*, *Armillaria mellea*, *Omphalia campanella*, *Polyporus schweinitzii*, and *Coniophora cerebella*. Throughout the range of cedar, the yellow ring rot caused by *Poria weirii* is probably the most serious. Cedar needle spot (*Keithia thujina*) sometimes reaches epidemic proportions in attacking seedlings and young trees. It attacks older trees, but such attacks are not as serious as those on younger trees. As much as 97 percent of western redcedar reproduction has been reported killed in its first season by this disease, which is apparently favored by high humidity and may be fostered by late spring snow cover (*23*, *31*).

Winter damage to young cedar trees is serious. Particularly heavy cedar damage has been reported when severe cold waves followed mild autumn weather (*6*).

More important than the diseases and insect enemies of western redcedar itself are the enemies of its associates. Most of its associates are much more susceptible to insect and pathological attacks than is cedar—a factor that tends to hasten the succession of cedar to its climax position.

RACES AND HYBRIDS

Studies of western redcedar from several sources in the United States and Canada have demonstrated wide variations in frost hardiness, which is indicative of definite racial variation in the species. Trees grown from inland seed sources were hardier than those from coastal areas.

Revised from "Silvics of Western Redcedar," by Raymond J. Boyd. U.S. Forest Serv. Intermountain Forest and Range Expt. Sta. Misc. Pub. 20, 14 pp. 1959.

LITERATURE CITED

(1) Andersen, H.E.
1953. Range of western redcedar (*Thuja plicata*) in Alaska. U.S. Forest Serv. Alaska Forest Res. Center Tech. Note 2, 1 p.

(2) British Columbia Dept. of Lands and Forests.
1957. Continuous forest inventory of British Columbia. 223 pp.

(3) Buckland, D. C.
1946. Investigations of decay on western redcedar. Canad. Jour. Res. C 24: 158–181.

(4) Daubenmire, R.
1952. Forest vegetation of northern Idaho and adjacent Washington and its bearing on the concepts of vegetation classification. Ecol. Monog. 22: 301–330.

(5) ———
1953. Nutrient content of leaf litter of trees in the northern Rocky Mountains. Ecology 34: 786–793.

[2] Robert Marshall. "Natural reproduction in western white pine." Unpublished manuscript. On file at the Intermountain Forest and Range Expt. Sta. 1938.

(6) Duffield, J. W., *et al.*
1955. Damage to western Washington forests from November 1955 cold wave. U.S. Forest Serv. Pacific Northwest Forest and Range Expt. Sta. Res. Note 129, 5 pp.
(7) Fischer, George M.
1935. Comparative germination of tree species on various kinds of surface-soil material in the western white pine type. Ecology 16: 606–611.
(8) Flint, Howard R.
1925. Fire resistance of northern Rocky Mountain conifers. Idaho Forester 7: 7–10, 41–43.
(9) Garman, E. H.,
1951. Seed production by conifers in the coastal region of British Columbia related to dissemination and regeneration. Canad. Dept. Lands and Forests, British Columbia Forest Serv. Tech. Pub. T. 35, 47 pp.
(10) ———
1953. A pocket guide to the trees and shrubs of British Columbia. Canad. Dept. Lands and Forests, British Columbia Forest Serv. Pub. B. 28, 102 pp.
(11) Gregory, R. A.
1957. Some silvicultural characteristics of western redcedar in Alaska. Ecology 38: 646–649.
(12) Haig, I. T.
1932. Second-growth yield, stand, and volume tables for the western white pine type. U.S. Dept. Agr. Tech. Bul. 323, 68 pp.
(13) ———, Davis, Kenneth P., and Weidman, Robert H.
1941. Natural regeneration in the western white pine type. U.S. Dept. Agr. Tech. Bul. 767, 99 pp.
(14) Hetherington, J. C.
1960. Seed dissemination and the influence of weather conditions on this process on the west coast of Vancouver Island. *In* Forest Research Review 1960. British Columbia Forest Serv., pp. 21–23.
(15) Isaac, Leo A.
1930. Seed flight in the Douglas fir region. Jour. Forestry 28: 492–499.
(16) ———
1939. Reforestation by broadcast seeding with small seeded species. U.S. Forest Serv. Pacific Northwest Forest and Range Expt. Sta. Res. Note 27, 10 pp.
(17) Jones, G. N.
1936. A botanical survey of the Olympic Peninsula, Washington. Wash. (State) Univ. Pub. in Biol., 286 pp.
(18) Knapp, Joseph Burke, and Jackson, Alexander Grant.
1914. Western redcedar in the Pacific Northwest. U.S. Forest Serv. (Reprinted from West Coast Lumberman, Feb. and March 1914.)
(19) Larsen, Julius Ansgar.
1940. Site factor variations and responses in temporary forest types in northern Idaho. Ecol. Monog. 10: 1–54.
(20) McMinn, R. G.
1960. Water relations and forest distribution in the Douglas-fir region on Vancouver Island. Forest Biol. Div., Canada Dept. Agr. Pub. 1091, 71 pp.
(21) Miller, F. G., *et. al.*
1927. The Idaho forest and timber handbook. Idaho (State) Univ. Bul. 22, 155 pp.
(22) Olson, D. S.
1932. Germinative capacity of seed produced from young trees. Jour. Forestry 30: 871.
(23) Porter, W. A.
1957. Biological studies on western redcedar blight caused by *Keithia thujina* Durand. Forest Biol. Div., Sci. Serv., Dept. Agr. Ottawa, 25 pp.
(24) Schmidt, R. L.
1955. Some aspects of western redcedar regeneration in the coastal forests of British Columbia. Canad. Dept. Lands and Forests, British Columbia Forest Serv. Res. Note 29, 10 pp.
(25) Schopmeyer, C. S., and Helmers, A. E.
1947. Seeding as a means of reforestation in the northern Rocky Mountain region. U.S. Dept. Agr. Cir. 772, 31 pp.
(26) Siggins, H. W.
1933. Distribution and rate of fall of conifer seeds. Jour. Agr. Res. 47: 119–128.
(27) Sudworth, George B.
1918. Miscellaneous conifers of the Rocky Mountain region. U.S. Dept. Agr. Bul. 680, 45 pp.
(28) Tarrant, Robert F., Isaac, Leo A., and Chandler, Robert F., Jr.
1951. Observations on litter fall and foliage nutrient content of some Pacific Northwest tree species. Jour. Forestry 49: 914–915.
(29) Taylor, Raymond F.
1950. Pocket guide to Alaska trees. U.S. Dept. Agr., Agr. Handb. 5, 63 pp.
(30) U.S. Forest Service.
1943. Western redcedar (*Thuja plicata*). Useful trees of U.S. 14. 4 pp.
(31) Weir, J. R.
1916. *Keithia thujina*, the cause of a serious leaf disease of the western redcedar. Phytopathology 6: 360–363.